145784

RUGGEDIZED SCINTILLATION DETECTOR FOR PORTAL MONITORS AND LIGHT PIPE INCORPORATED THEREIN

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to radiation detectors and, more specifically, to a suspension and protection system for portal monitoring radiation detectors.

[0002] Existing portal monitoring radiation detectors are often subjected to varying degrees of shock or vibration during normal usage. In some cases, the degree of shock or vibration exposure may be quite severe. Deleterious effects from shock and vibration may include high background counts, noise in the detector's response spectrum, and even breakage of the detector.

[0003] Existing shock and vibration isolation systems for radiation detectors typically consist of either an elastomeric boot that is telescoped over the radiation detector, or a foam pad that is wrapped around the radiation detector. Due to size constraints in portal monitoring radiation detectors, these methods are commonly not even attempted. In many cases, the crystal component of the detector is simply wrapped in a reflective material and then inserted into a 1 mm thick stainless steel housing. A typical crystal component is in the shape of a 2" x 4" rectangle that is 16" long. It may be in other shapes, however, one common variation being a 4" x 4" square that is also 16" long. These rectangular and square crystal components are then commonly coupled to a photomultiplier tube (PMT).

Typical portal monitoring radiation detectors use round PMTs that are easily obtained and tend to have uniform resolution independent of where light interacts with the photocathode. The crystal is coupled to the round PMT with a pseudo rounded-rectangular light pipe that has an efficiency of approximately 65% based on an 8" square inch surface area for the crystal being exposed to approximately 65% of the PMT surface area (for a 3" round PMT). The crystal and the PMT are commonly glued to the light pipe interface, but frequently become uncoupled, however, due to shock, vibration, temperature fluctuations, or other typical field exposures. Moreover, the stainless steel housing and any internal isolation systems that may be employed typically reduce the detector's effectiveness to measure gamma radiation at low energy levels due to their attenuating effects.

[0004] Finally, the light pipes and photomultiplier tubes (PMTs) used in these types of detectors are not optimized for light transmission and collection.

BRIEF DESCRIPTION OF THE INVENTION

[0005] This invention provides a ruggedized portal monitoring radiation detector with a unique suspension/protection system. Generally, the detector will include a scintillation crystal (usually sodium iodide doped with thallium, but not excessively so); an axial suspension system for both the PMT as well as the scintillating crystal; a radial suspension system for the scintillating crystal to protect it from shock and vibration and to reduce gamma attenuation; an optically modeled light pipe to transmit the light generated by the

crystal to the PMT; a square photomultiplier tube (PMT); and an aluminum housing enclosing the crystal to further reduce the attenuation of low energy gamma rays.

[0006] More specifically, the crystal in the exemplary embodiment has either a rectangular or a square configuration. The crystal may be a sodium iodide crystal doped with thallium (Nal(Tl)). Such crystals have been used in radiation detectors since 1920, and have well known properties for gamma sensitivity, spectral resolution, and light output.

[0007] The detector in the exemplary embodiment incorporates a square PMT of the type typically utilized in medical imaging applications. These PMT's are also easy to obtain and are known to have excellent spectral resolution properties. The detector will utilize quartz as the material of choice for the light pipe; however, materials with similar indices of refraction may also be used if they offer additional benefits such as reduced cost, ease of manufacture, etc.

[0008] The detector's radial suspension system includes plastic corner brackets or rails located on all four longitudinal corners of the rectangular crystal, running along approximately 90% of its length. These plastic corner brackets may be made of any suitable and readily available plastic that has a low friction coefficient. The plastic corner brackets are lined on inside surfaces thereof with a shock absorbing foam. This foam is a visco-elastic type foam that has a high degree of shock isolation and also acts as a vibration dampening material when under compression. Other types of foam may be used

however, if they are suitable for the same purpose. Since the corner brackets are fitted along the four longitudinal corners of the crystal, when inserted into a housing, they will be under some degree of compression, thus allowing them to both dampen vibration as well as protect the crystal from shock. Additionally, similar foam lined rails may be placed along the four faces of the crystal with adequate spacing to suspend the crystal inside of the housing and away from the side walls.

[0009] The detector's axial suspension system includes two annular wave springs located at one end of the crystal, remote from the PMT. Compression plates to evenly distribute the load of the springs and the crystal are located on either side of the springs. The axial suspension arrangement also includes an annular wave spring around the base of the PMT. These axial suspension springs are used to maintain optical coupling between the crystal, the light pipe and PMT. Foam pads or other similar materials may be used in conjunction with the other design components to achieve the same effect as the wave springs around either the PMT or at the ends of the crystal.

[0010] The detector housing includes a main or crystal housing enclosing the crystal component and a cylindrical cover that encloses the PMT and associated electronics package. The main housing portion may be composed of a thin-walled aluminum material that will reduce the degree of gamma radiation attenuation that occurs, thus enabling the detector to measure lower energy levels of gamma radiation. Additionally, with the incorporation of the suspension system as described above, the crystal is off-

set from the housing wall, thus allowing for additional protection of the side of the detector in the event that the housing is impacted in some way. Finally, since the crystal is not in intimate contact with metal, an air gap or layer of insulating air is created between it and the housing. Thus, the crystal is also less likely to suffer from thermal shock.

[0011] Accordingly, in one aspect, the invention relates to a radiation detector comprising a housing, an elongated, rectangular crystal having four longitudinally extending corners, and a photomultiplier tube both supported in the housing, with a light pipe located axially between respective facing ends of the photomultiplier tube and the crystal; and a plurality of elongated rails extending along respective ones of the longitudinally extending corners of the rectangular crystal, establishing an air gap between the crystal and the housing.

[0012] In another aspect, the invention relates to a radiation detector comprising a rectangular housing, an elongated, rectangular crystal having four longitudinally extending corners supported and a photomultiplier tube supported in the housing with a light pipe axially supported between the photomultiplier tube and the crystal; and a plurality of elongated corner brackets extending along respective ones of the elongated corners of the rectangular crystal; wherein the photomultiplier tube is substantially square in cross section; the light pipe having a substantially square face interfacing with the photomultiplier tube and a substantially rectangular face interfacing with the crystal.

[0013] In still another aspect, the invention relates to a radiation detector comprising a housing, an elongated, rectangular crystal having four longitudinally extending corners, and a photomultiplier tube both supported in the housing, with a light pipe located axially between respective facing ends of the photomultiplier tube and the crystal; a plurality of rails including shock absorbing material extending along the crystal, creating a gap between the crystal and the housing, for protecting the crystal from radial shock and vibration; and a plurality of resilient members opposite ends of the crystal for protecting the crystal from axial shock and vibration.

[0014] In still another aspect, the invention relates to a light pipe for coupling a scintillation crystal to a photomultiplier tube comprising a rectangular face for engaging a similarly-shaped face on the scintillation crystal and a square face for engaging a similarly-shaped photomultiplier tube.

[0015] The invention will now be described in detail in connection with the above identified drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIGURE 1 is a front perspective view of a portal monitoring radiation detector in accordance with a first exemplary embodiment;

[0017] FIGURE 2 is a side elevation of the detector shown in Figure 1;

[0018] FIGURE 3 is a front elevation of the detector shown in Figures 1 and 2;

[0019] FIGURE 4 is an exploded perspective view of the detector shown in Figures 1-3;

[0020] FIGURE 5 is a perspective view of a light pipe component taken from Figure 4;

[0021] FIGURE 6 is a front elevation of the light pipe shown in Figure 5; and

[0022] FIGURE 7 is a bottom plan view of the detector shown in Figure 6.

DETAILED DESCRIPTION OF THE INVENTION

[0023] With initial reference to Figures 1-3, a portal monitoring radiation detector 10 includes a housing including a main or crystal housing 12 and a PMT cover 14 joined together at a housing interface 16. The main housing portion 12 is of generally elongated rectangular shape, having top and bottom walls 18, 20, side walls 22, 24 and an end wall 26. The opposite end of the crystal housing is enlarged, particularly in terms of the height dimension of the housing, and includes top and bottom walls 28, 30, side walls 32, 34 and an apertured end wall 36 joined to the remainder of the main housing 12. The opposite end wall 37 (also apertured) is sized to mate with a similarly shaped flange 38 on one end of the otherwise cylindrical PMT cover 14, facilitating the joining of the crystal housing 12 and PMT cover 14 by means of screw fasteners 40 or other suitable means. The

crystal housing 12 may be constructed of thin-walled aluminum that will reduce the degree of gamma radiation detection, enabling the measurement of lower energy gamma radiation.

[0024] Turning now to Figure 4, the internal components of detector 104 are shown in exploded form. The primary components are the scintillation crystal 42 and the PMT 44 arranged on, and adhered to opposite sides of a light pipe 46.

[0025] The crystal 42 is shown wrapped in a reflective tape (e.g., Teflon®) and sized and shaped to fit within the main or crystal housing 12, with clearance to accommodate the suspension system described further herein. The crystal itself may be a sodium iodide crystal doped with thalium (Nal(Tl)). Typical measurements for the crystal may be 2" wide x 4" deep x 16" long, or 4" wide x 4" deep x 16" long. These particular dimensions are not exclusive, but represent the general boundaries that those knowledgeable in the art have used previously to build radiation detectors for these purposes.

[0026] The PMT 44 in the exemplary embodiment is square in shape. For the 2" x 4" x 16" crystal type detector, a 3" x 3" square PMT will be utilized.

[0027] Light pipe 46 (see also Figures 5-7) is interposed between the crystal 42 and PMT 44 and has a rectangular face 48 for engagement with similarly shaped face 50 of the crystal, and a square face 52 for engagement with a similarly shaped face 54 of the PMT.

This means that, based on the above noted dimensions, 8 sq. in. of surface area emitting light from the crystal is being optically coupled to a 9 sq. in. surface area on the light pipe, thus maximizing the light transfer. Angled surfaces 56, 58 extend between the square face 52 and the back side of rectangular face 48, forming flanges 60, 62 along the vertical side edges of the light pipe. During assembly, the light pipe 46 is oriented as shown in Figure 4 and couples the crystal 42 to the PMT 44 via a conventional optical gel on its opposite faces 48 and 52. As well understood in the art, the light pipe transmits light generated by the crystal 42 to the PMT 44. The opposite end of the PMT 44 is coupled to a conventional electronic package 64 that, when assembled, projects from the distal end of the PMT cover 14 as best seen in Figure 2, with cables (not shown) extending from the cable bushing 66.

[0028] Plastic corner brackets or rails 68 (three of four shown) are located along the four corner edges of the crystal 42, and extend along about 90% of the length of the crystal. Each corner bracket includes a pair of elongated edge surfaces 70, 72 arranged perpendicular to each other so as to engage respective perpendicular corner edges of the crystal. The inward facing surfaces of the corner brackets 68 are lined with a shock absorbing foam, for example, a visco-elastic type foam 69 that exhibits a high degree of shock isolation, and that also acts to dampen vibration when under compression. In this regard, the corner brackets in the fully assembled detector are in compression in a direction substantially perpendicular to a longitudinal axis of the crystal 42. The brackets 68 themselves are constructed of any

suitable plastic material with a low coefficient of friction to facilitate sliding insertion of the crystal 42 into the main housing 12. This arrangement also provides an air gap between the crystal and the housing, on all four sides of the crystal. This layer of insulating air provides additional thermal and impact protection for the crystal. In an alternative arrangement, generally similar foam-lined rails may be placed along the four faces of the crystal, with or without the corner brackets or rails.

[0029] The detector suspension system also includes a pair of annular wave springs 74, 76 located axially between a pair of rectangular compression plates 78, 80 (e.g., .030 inch thick stainless steel). The springs are a suitable metal but could also be ceramic. This assembly of plates and springs is located axially between the forward face 88 of the crystal 14 and the forward end wall 26 of the housing 12. A similar but larger diameter annular wave spring 82 is also placed around one end of the electronic package 64, sandwiched between annular flange 84 and end wall 86 of the PMT cover 14. Thus, not only is the crystal 42 protected from shock and vibration by a radial suspension system, but also by an axial suspension system that, in addition, maximizes the coupling of the crystal 42 and PMT 44 to the light pipe 46. It will be appreciated that the wave springs 74, 76 and 82 may be replaced by suitable foam pads or other suitable resilient members.

[0030] Testing with the above described detector conforms that there is virtually no loss of spectral

resolution or light output by utilizing the crystal, PMT and light pipe configuration as described above.

[0031] The detector as described may be used as a gamma radiation detector inside a housing and placed near a portal through which people and vehicles, cargo or other similar things may pass. It may also be beneficial in portals that "see" large amounts of vibration such as near trains and the like.

[0032] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.